

Application of Discriminant Analysis in Finance



Forecasting Financial Distress and Bankruptcy of Companies



The authors reviewed the possibility of DA in forecasting the financial health of companies based on data from 105 Bankrupt and 2058 non-bankrupt companies from 1970 to 1976.

Forecasting the direction of Exchange Rate of Currencies

“The Use of Discriminant Analysis in Forecasting the Exchange Rate Movements”

By William Folks and Stanley Stansell (1975)

Published in: Journal of International Business Studies
Vol(6), No. 1, pp. 33-50

Movement of Exchange Rate of Countries

Exchange Rate has gone down

Relative to Dollar their currency rate has gone down by 5% or more over two year period.

5 countries that devalued their currency in 1963-64 and 14 countries that devalued their currency in 1965-66 were considered in this group

Exchange Rate has not gone down

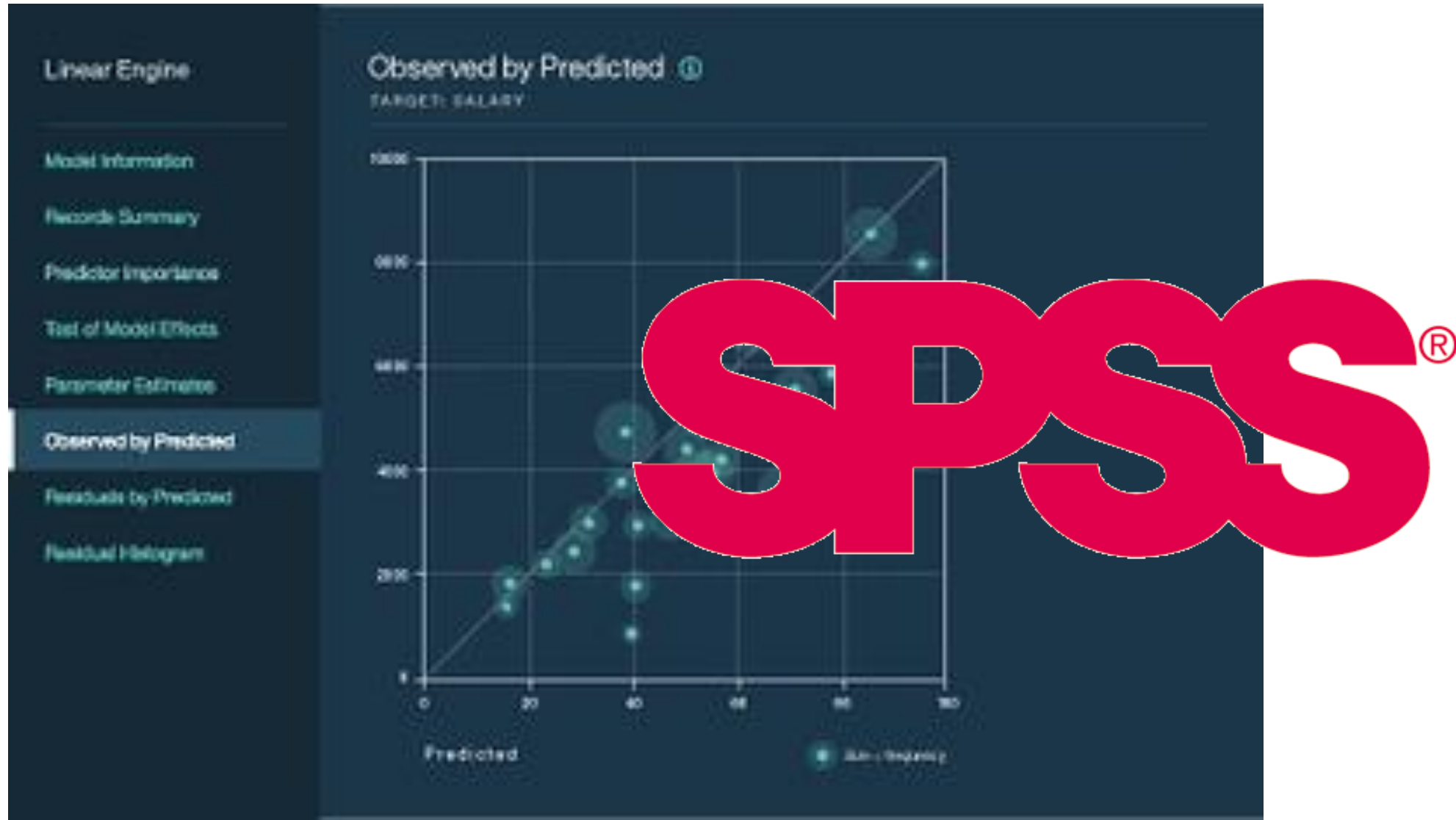
The currency rate has never gone down by 5% or more over two year period.

5 countries that did not devalue their currency in 1963-64 were randomly selected and another 14 countries that did not devalue their currency in 1965-66 were randomly selected in this group

**TRAINING
SAMPLE**

	De-valuing Countries	Non- Devaluing Countries	Discriminating Variables (Micro Economic Parameters)
	Brazil Chile Uruguay Venezuela Korea	Australia Mexico Japan Denmark Spain	Reserve Growth Ratio (R) $= \frac{Re\ reserves(t)}{Re\ reserves(t-1)}$ Extended Money Supply Ratio (M) $= \frac{M2(t)}{M2(t-1)}$ Price Index Ratio (P) $= \frac{Consumer\ Price\ Index(t)}{Consumer\ Price\ Index(t-1)}$
	UK Iceland Denmark	Netherland Venezuela Turkey	
D = 0.34 R - 0.47 P + 0.008 T - 0.02 ISR - 1.053 CBDR			
1965-66	Spain Brazil Chile Colombia Peru Uruguay Israel New Zealand Ghana Sri Lanka	Norway Japan Germany El Salvador India Italy Honduras Thailand Tunisia Sweden	$= \frac{Exports(t)}{Imports(t)}$ Investment Service Ratio (ISR) $= \frac{Investment\ Service\ Obligation(t)}{Re\ reserves(t)}$ Marginal Propensity to Import Ratio (I) $= \frac{Imports(t)}{Imports(t-1)}$ Central Bank Discount Rate Ratio (CBDR) $= \frac{Central\ Bank\ Discount\ Rate(t)}{Central\ Bank\ Discount\ Rate(t-1)}$

HOW TO PERFORM DISCRIMINANT ANALYSIS IN



Variables in the file

- id: The patient identity number
- Schizo: Consensus diagnosis of Schizophrenia of the respondent (0 for 'non-schizophrenic' 1 for patients detected with 'schizophrenia')
- Lie_Score: A score of the patient in the lie scale
- F_Score: A score of the patient in the F scale
- K_Score: A score of the patient in the K scale
- HS: Hypochondriasis score of the patient
- Dep: Self concept score. This is a continuous variable
- Hy: Hysteria score of the patient
- Psycho: Psychopath score of the patient
- Mf: Masc / Fem score of the patient
- Pa: Paranoia score of the patient
- Pt: Psychasthenia score of the patient
- Hypo_ma: Hypomania score of the patient
- Intro: Introversion score of the patient



	<i>id</i>	Schizo	Lie_score	F_score	K_Sco...	Hs	Dep	Hy	Psycho	Mf	Pa	Pt	Sc	Hypo_ma	Intro
1	A01AC233	0	50	60	41	60	62	58	70	49	64	67	59	57	79
2	A01AP233	0	37	73	47	71	87	78	77	61	83	87	86	51	79
3	A02AC259	0	57	50	55	52	49	48	47	55	49	51	52	64	60
4	A02AP159	1	70	76	53	67	70	53	68	63	86	63	80	67	63
5	A03MC233	0	53	46	49	39	45	50	49	43	49	42	39	35	60
6	A03MP233	0	40	55	47	73	77	69	77	41	61	76	69	62	66
7	A04MC259	0	53	55	57	39	60	56	66	49	52	51	53	42	64
8	A04MP259	0	53	78	61	54	66	74	87	53	68	61	72	53	65
9	A05AC256	0	40	58	53	50	62	59	70	26	68	50	47	51	56
10	A05AP156	0	47	62	48	69	74	59	75	67	63	60	69	78	56
11	B02AC251	0	50	50	63	45	47	48	54	37	58	42	45	49	48
12	B03AC136	0	67	68	57	56	79	66	75	57	45	56	53	44	51
13	B03AP136	0	47	68	42	67	61	61	60	57	66	65	73	60	50
14	B04MC155	0	57	55	53	53	61	55	58	51	51	52	52	49	51
15	B04MP155	0	43	60	48	79	92	89	81	61	81	75	63	51	65
16	B05AC152	0	47	44	53	44	48	53	45	49	34	38	41	56	43
17	B05AP152	0	43	80	50	49	52	48	88	45	78	72	71	67	57
18	B06MC252	0	53	58	61	39	43	39	40	66	42	43	42	51	53
19	B06MP252	0	43	55	49	56	60	59	58	30	71	56	54	55	67
20	B07AP148	1	48	84	44	74	58	57	55	84	75	88	85	87	58

Data View

Variable View



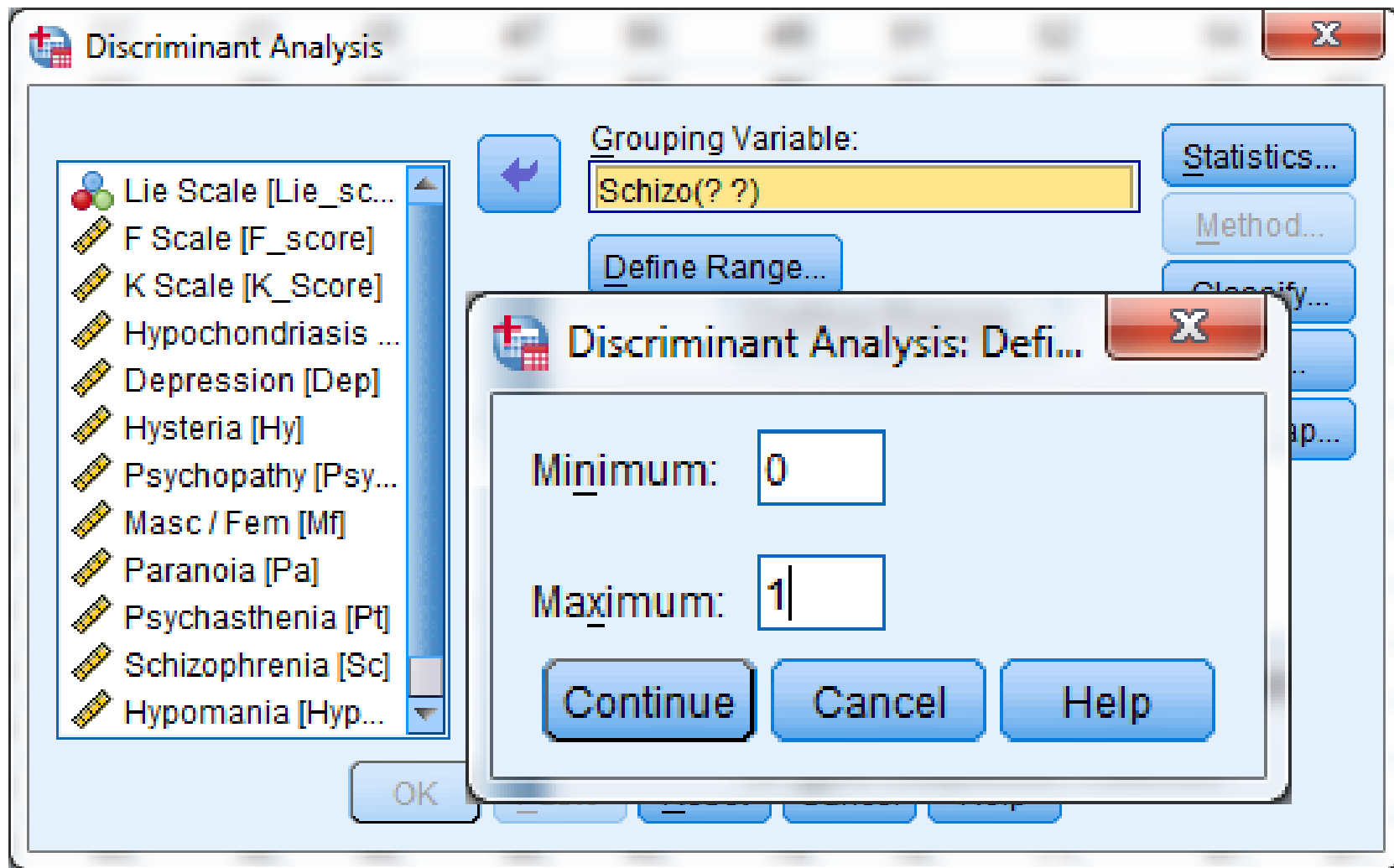
- Reports
- Descriptive Statistics
- Tables
- Compare Means
- General Linear Model
- Generalized Linear Models
- Mixed Models
- Correlate
- Regression
- Loglinear
- Neural Networks
- Classify**
- Dimension Reduction
- Scale
- Nonparametric Tests
- Forecasting
- Survival
- Multiple Response
- Missing Value Analysis...
- Multiple Imputation
- Complex Samples
- Simulation...
- Quality Control
- ROC Curve...

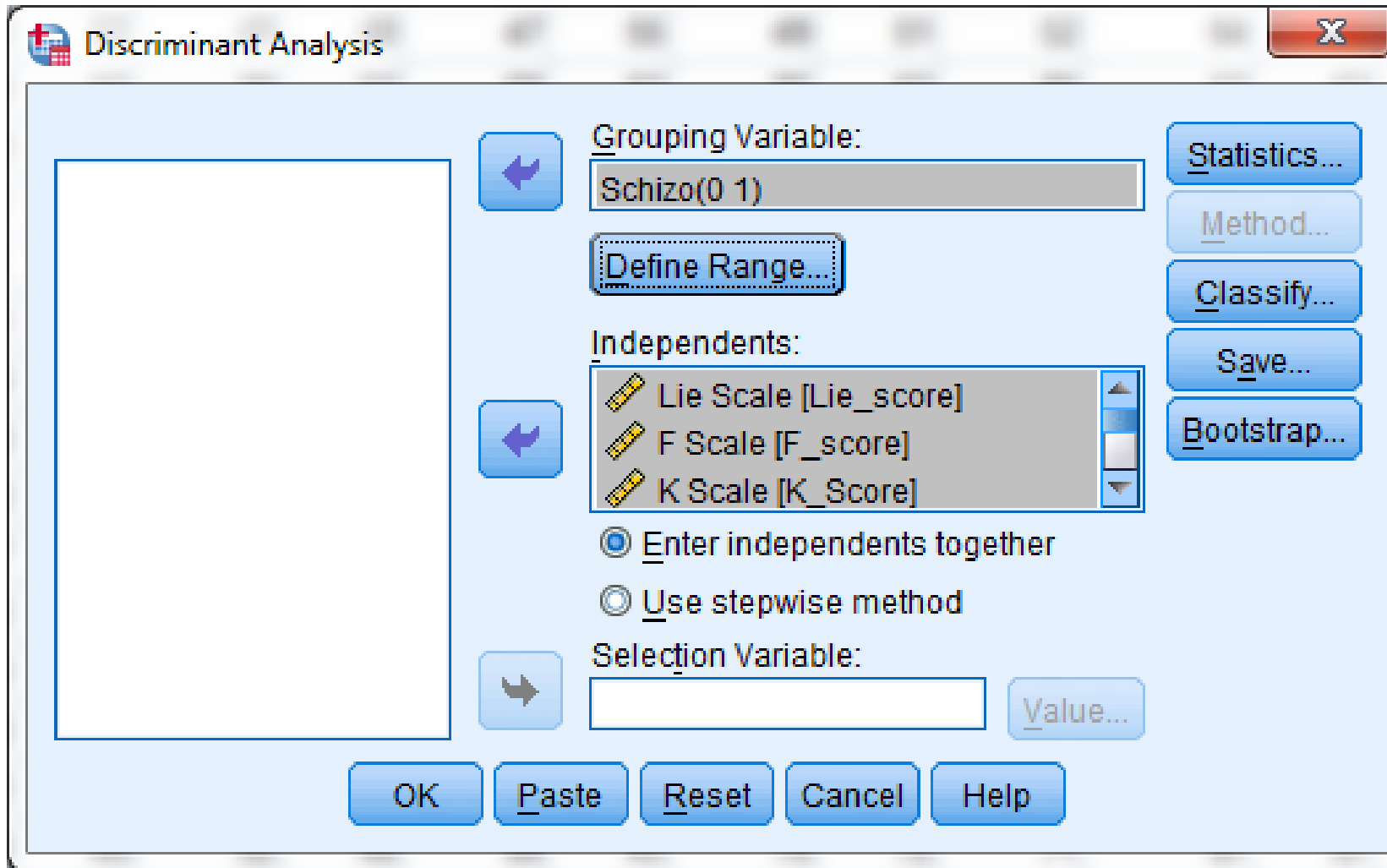


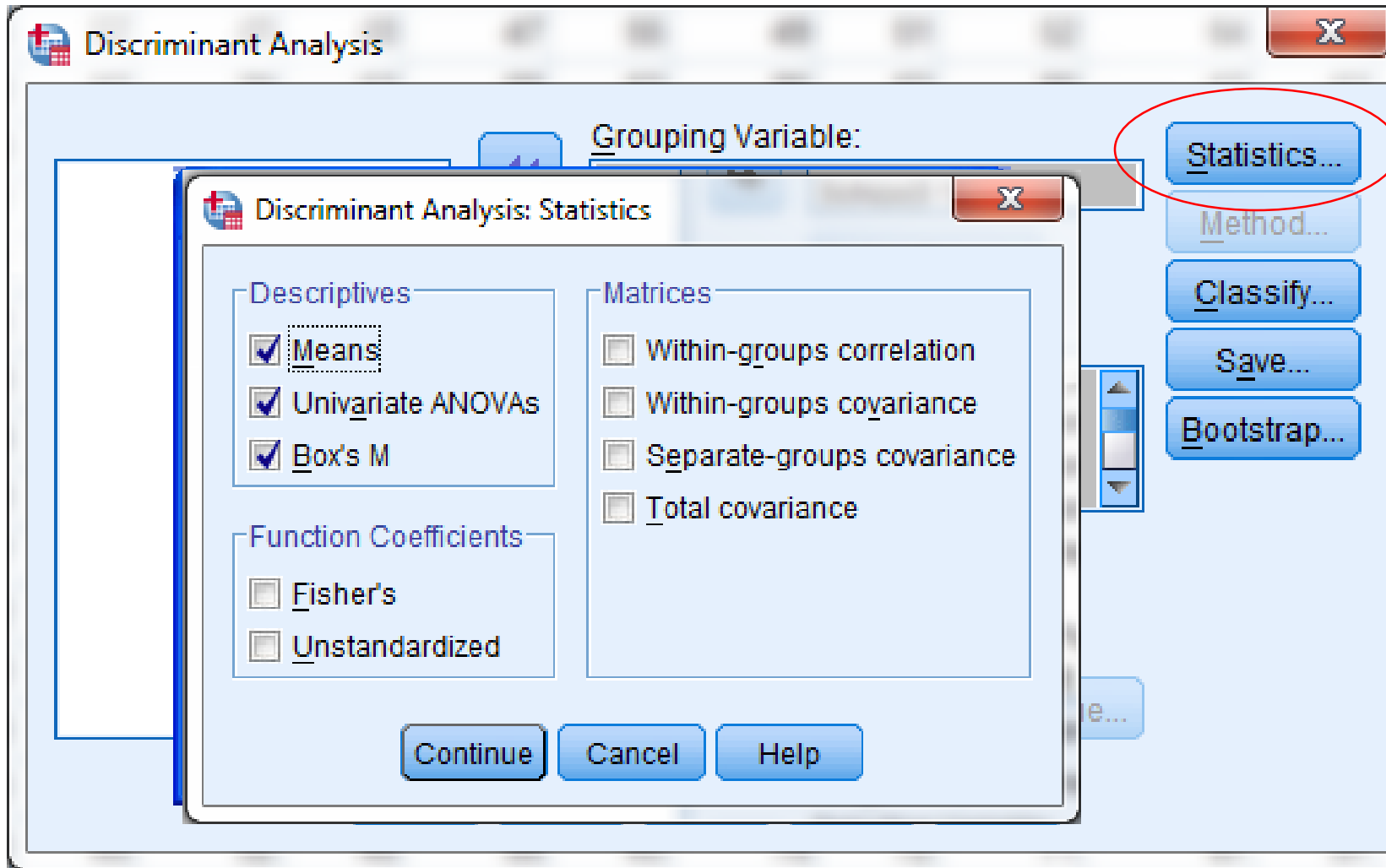
5 :

	id	Schiz	ts	Dep	Hy	Psycho	Mf	Pa	Pt	Sc	Hypo_ma	Intro	var	var	v
1	A01AC233		60	62	58	70	49	64	67	59	57	79			
2	A01AP233		71	87	78	77	61	83	87	86	51	79			
3	A02AC259		52	49	48	47	55	49	51	52	64	60			
4	A02AP159		67	70	53	68	63	86	63	80	67	63			
5	A03MC233		39	45	50	49	43	49	42	39	35	60			
6	A03MP233		73	77	69	77	41	61	76	69	62	66			
7	A04MC259		39	60	56	66	49	52	51	53	42	64			
8	A04MP259						53	68	61	72	53	65			
9	A05AC256						26	68	50	47	51	56			
10	A05AP156						67	63	60	69	78	56			
11	B02AC251						37	58	42	45	49	48			
12	B03AC136						57	45	56	53	44	51			
13	B03AP136						57	66	65	73	60	50			
14	B04MC155						51	51	52	52	49	51			
15	B04MP155		79	92	89	81	61	81	75	63	51	65			
16	B05AC152		44	48	53	45	49	34	38	41	56	43			
17	B05AP152		49	52	48	88	45	78	72	71	67	57			
18	B06MC252		39	43	39	40	66	42	43	42	51	53			
19	B06MP252		56	60	59	58	30	71	56	54	55	67			
20	B07AP146		74	56	57	55	61	75	63	65	67	59			
21	B08MP223		46	41	50	54	45	52	50	54	62	52			
22	B09AP148	0	43	60	41	49	50	46	65	63	48	67	49		

Data View Variable View







Uses of the Descriptive Statistics

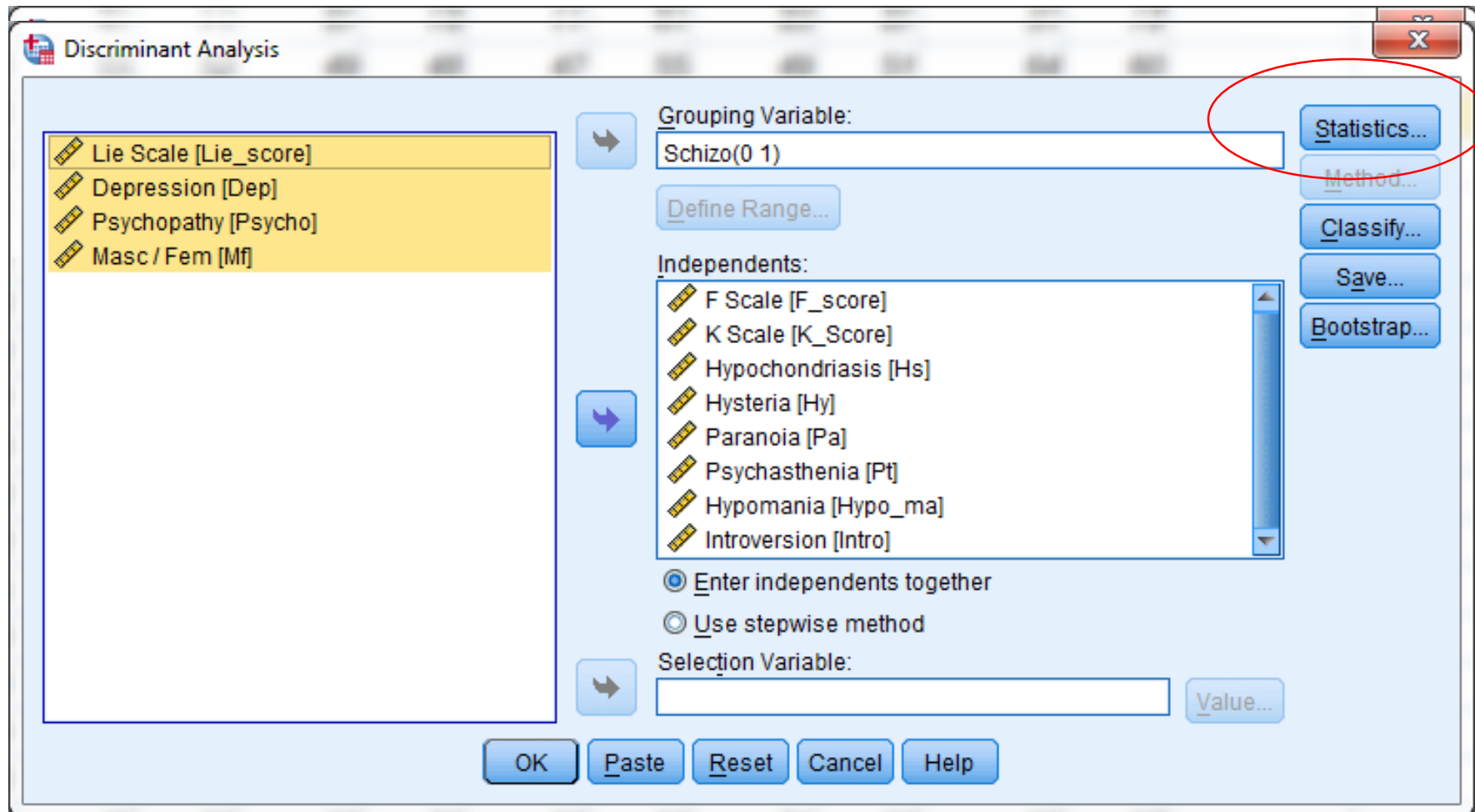
- The entire data set shall now be classified as schizophrenic and non-schizophrenic
- Means: Displays total and group means, as well as standard deviations for the independent variables.
- Univariate ANOVAs: Performs a one-way analysis-of-variance test for equality of group means for each independent variable.
- Box's M: A test for the equality of the group covariance matrices. For sufficiently large samples, a non-significant p value means there is sufficient evidence that the matrices do not differ. The test is sensitive to departures from multivariate normality.

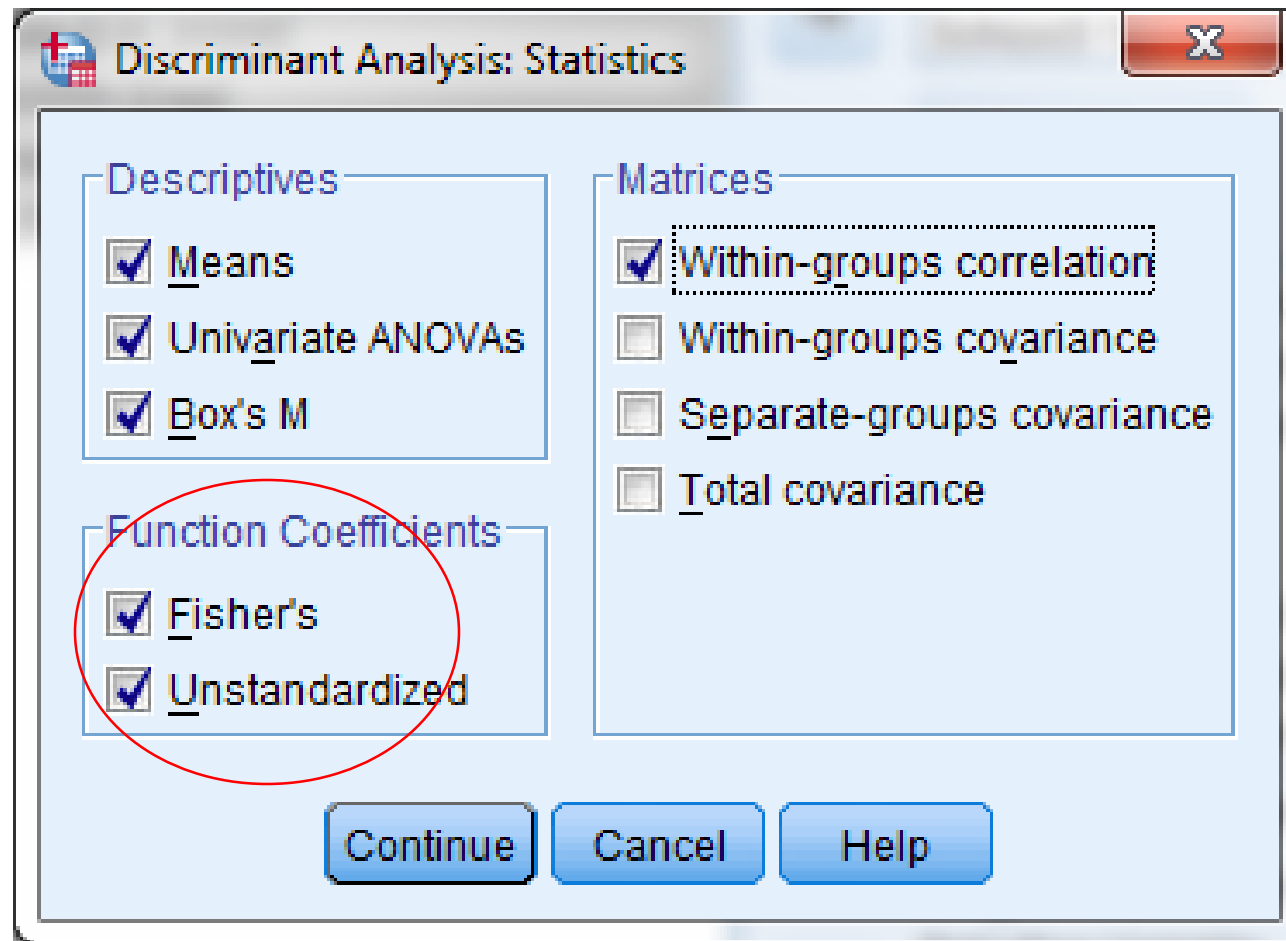
Identifying Useful Variables

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
Lie Scale	.999	.310	1	400	.578
<u>F Scale</u>	.904	42.517	1	400	.000
<u>K Scale</u>	.985	6.094	1	400	.014
<u>Hypochondriasis</u>	.982	7.507	1	400	.006
Depression	.993	2.689	1	400	.102
<u>Hysteria</u>	1.000	.003	1	400	.954
Psychopathy	.985	6.135	1	400	.014
Masc / Fem	.995	2.182	1	400	.140
<u>Paranoia</u>	.920	34.813	1	400	.000
<u>Psychasthenia</u>	.967	13.529	1	400	.000
<u>Hypomania</u>	.954	19.084	1	400	.000
<u>Introversion</u>	.980	7.983	1	400	.005

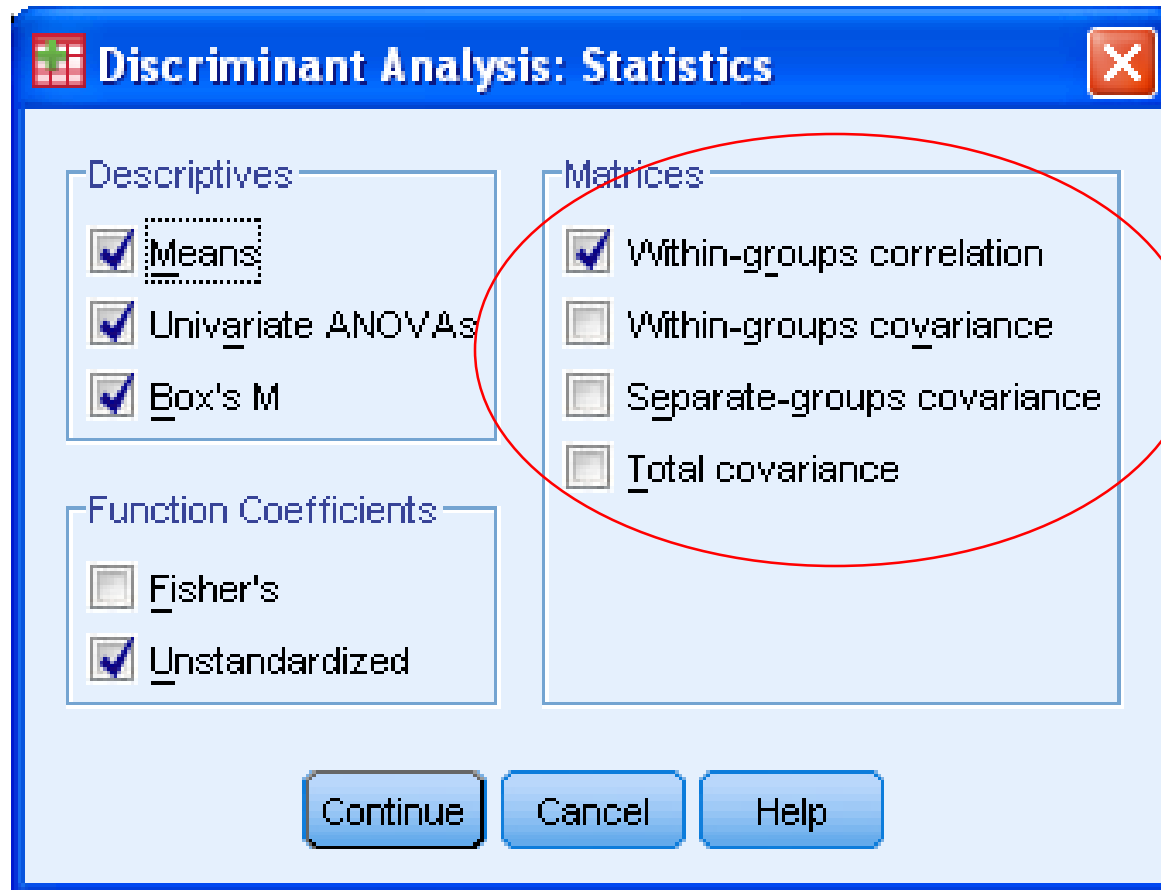
Bring back the less important variables





Function coefficients

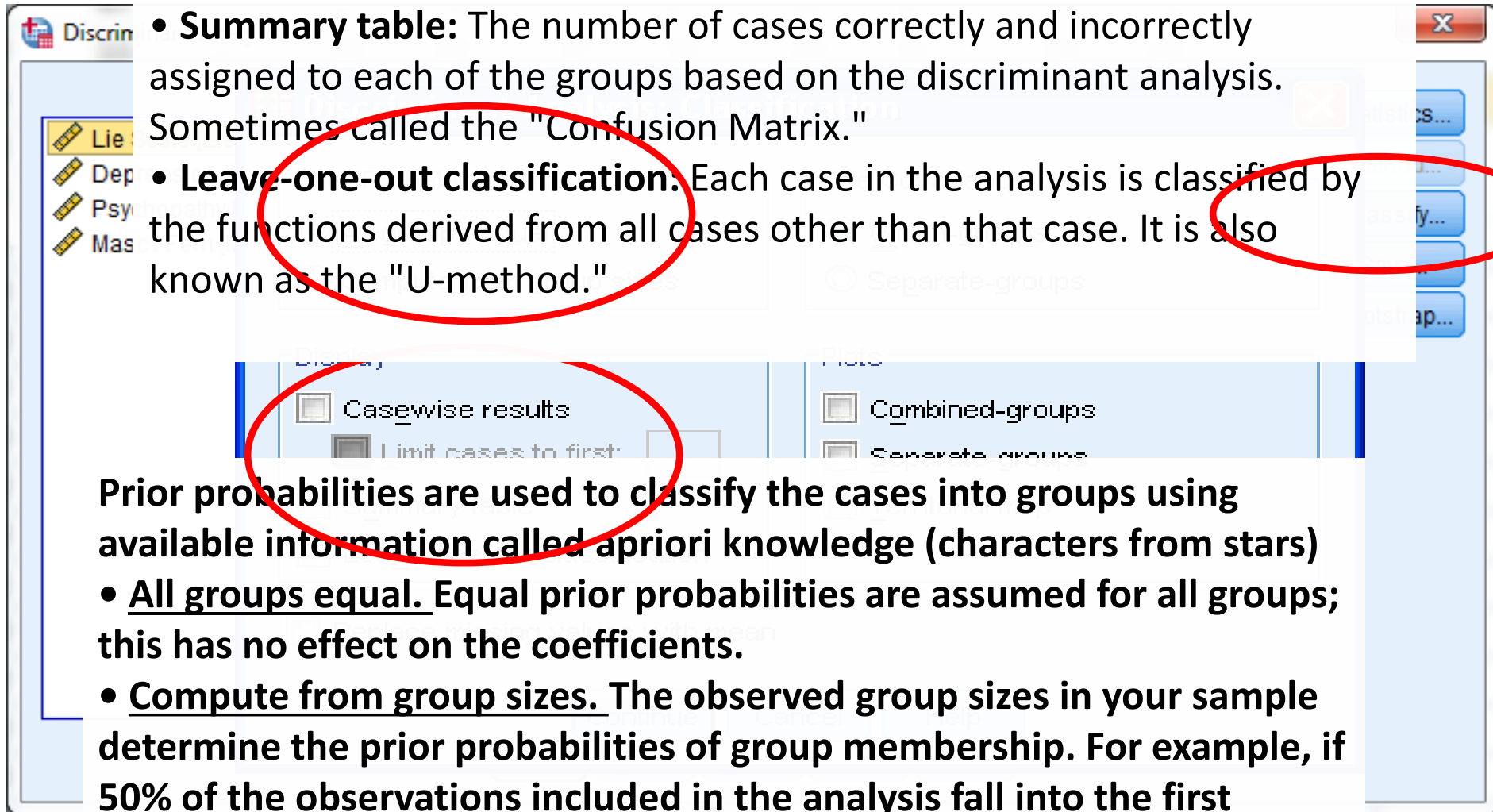
- There are different methods of computing the discriminating function.
- The most popular are Maximum likelihood rule, Bayes rule and the Fisher's linear rule.
- However, SPSS has only two rules. The Bayes rule is excluded.
- In Fisher's rule a separate set of classification function coefficients is obtained for each group, and a case is assigned to the group for which it has the largest classification score



- **Casewise results:** predicted group, posterior probabilities, and discriminant scores are displayed for each case.

- **Summary table:** The number of cases correctly and incorrectly assigned to each of the groups based on the discriminant analysis. Sometimes called the "Confusion Matrix."

- **Leave-one-out classification:** Each case in the analysis is classified by the functions derived from all cases other than that case. It is also known as the "U-method."



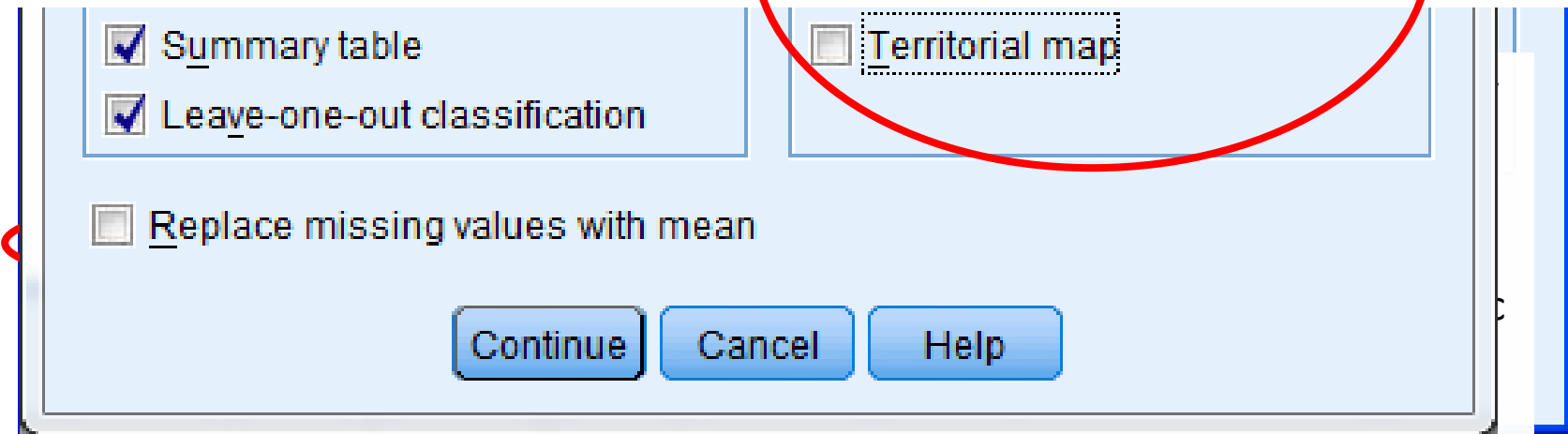
Prior probabilities are used to classify the cases into groups using available information called a priori knowledge (characters from stars)

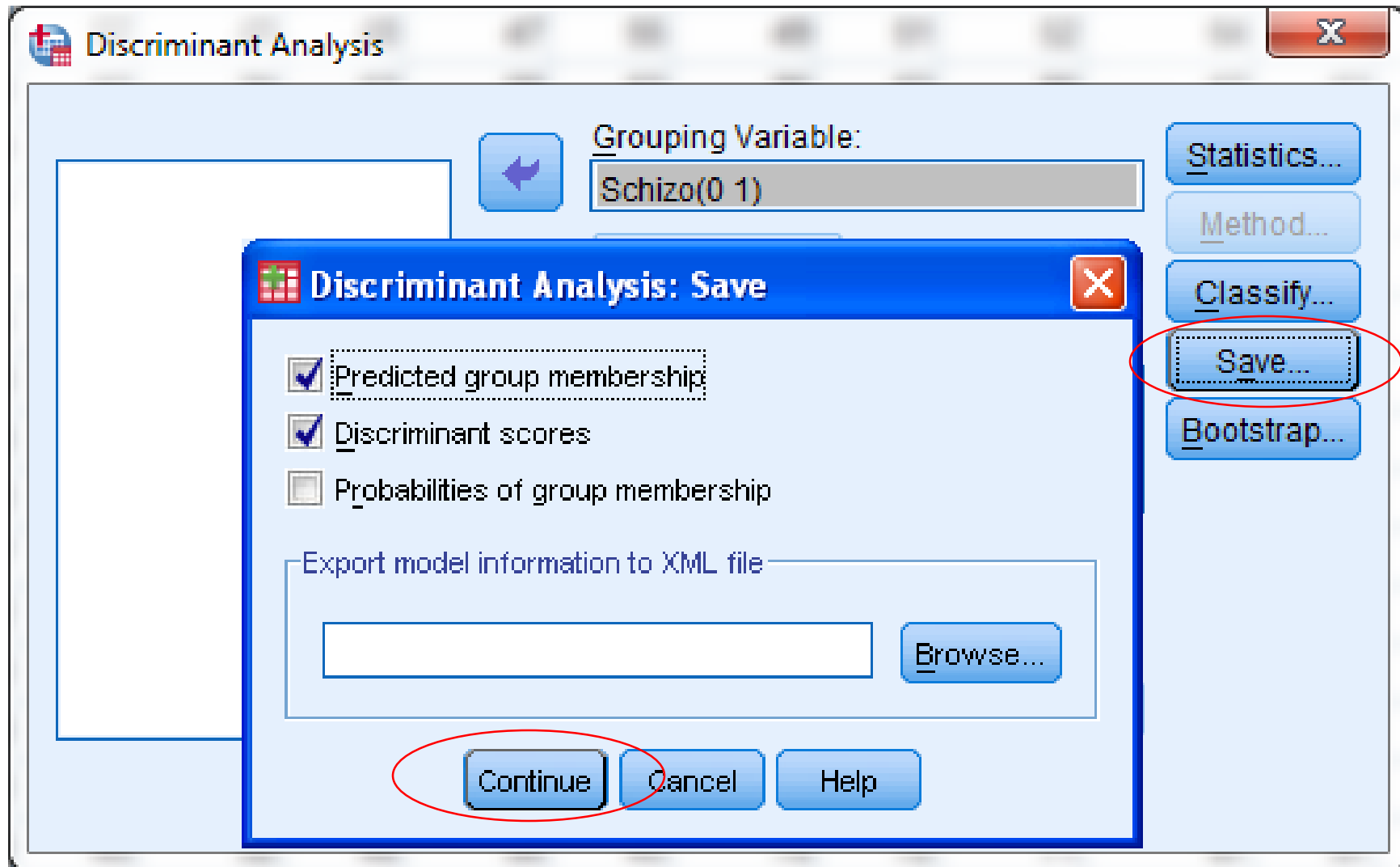
- **All groups equal.** Equal prior probabilities are assumed for all groups; this has no effect on the coefficients.

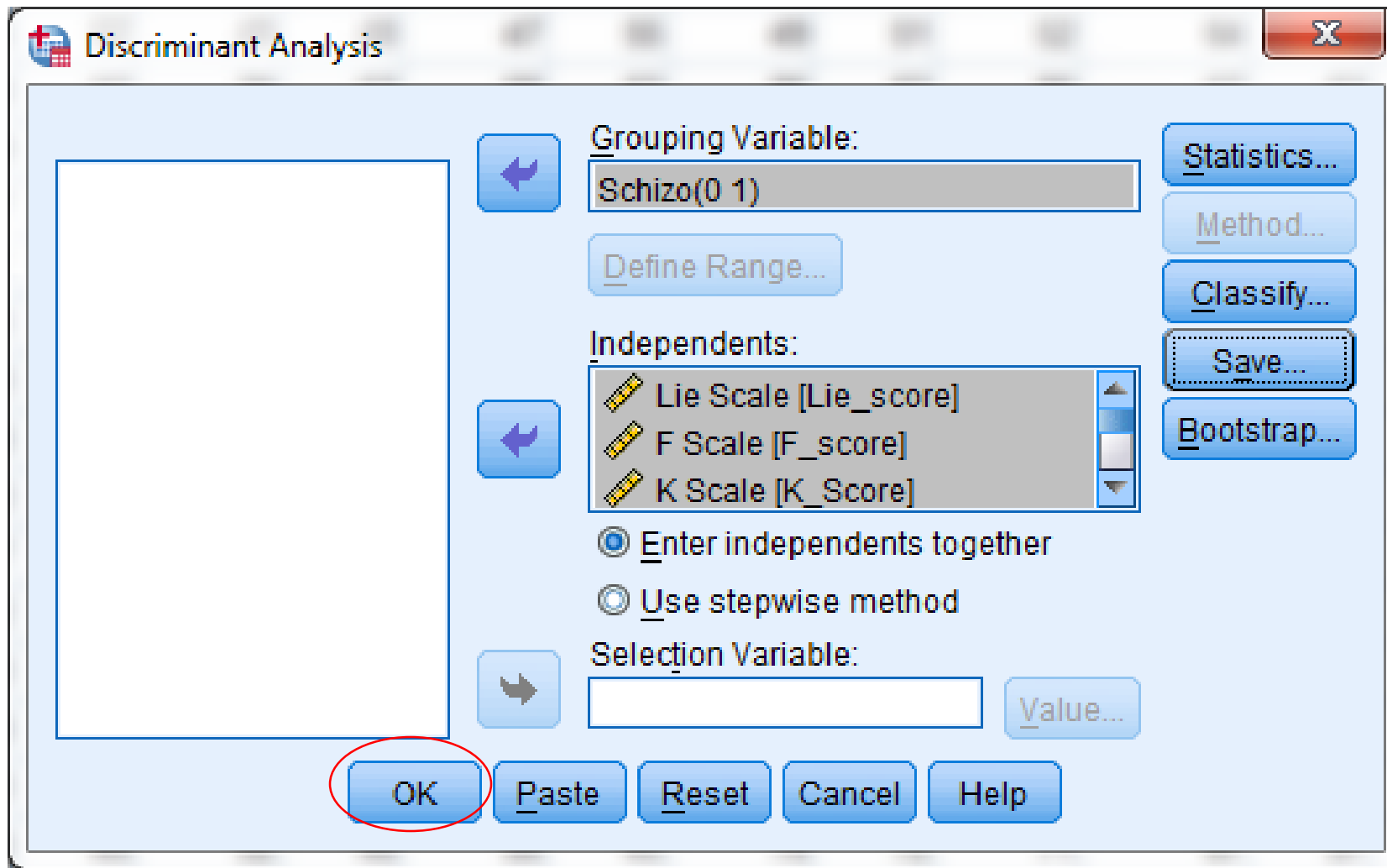
- **Compute from group sizes.** The observed group sizes in your sample determine the prior probabilities of group membership. For example, if 50% of the observations included in the analysis fall into the first group, 25% in the second, and 25% in the third, the classification coefficients are adjusted to increase the likelihood of membership in the first group relative to the other two.

- **Combined-groups:** Creates an all-groups scatterplot of the first two discriminant function values. If there is only one function, a histogram is displayed instead.
- **Separate-groups:** Creates separate-group scatterplots of the first two discriminant function values. If there is only one function, histograms are displayed instead.
- **Territorial map:** A plot of the boundaries used to classify cases into groups based on function values. The numbers correspond to groups into which cases are classified. The mean for each group is indicated by an asterisk within its boundaries. The map is not displayed if there is only one discriminant function.

NOT TO BE USED IF THERE IS ONE DISCRIMINANT FUNCTION ONLY i.e. TWO CATEGORIES OF THE DEPENDENT VARIABLE







Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
F Scale	.904	42.517	1	400	.000
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Hypomania	.954	19.084	1	400	.000
Introversion	.980	7.983	1	400	.005

The highly significant p-values indicates that the difference between the two groups for all the above variables are significant.

Results of the Box's M Test

- The null hypothesis of the test is that the variance-covariance matrix of the two groups does not differ significantly.
- The analysis is based on the assumption as in the null hypothesis.
- But it is not an important assumption especially in case of large samples (robustness issues).

Test Results

Box's M		123.261
F	Approx.	1.254
	df1	91
	df2	42118.087
	Sig.	.054

Tests null hypothesis of equal population covariance matrices.

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.172 ^a	100.0	100.0	.383

a. First 1 canonical discriminant functions were used in the analysis.

The value of the canonical correlation is 0.383 i.e. $R^2 = 0.383 \times 0.383 = 0.1467$

Thus, 14.67% variation in the grouping variable is explained.

Canonical Correlation

- It is the multiple correlation between the predictors and the discriminant function.
- Here as there is only one discriminating function so the value is a measure of the overall model fit.
- It can be explained like the value of R^2 in regression.

Wilks' Lambda

- It indicates the significance of the discriminant function

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.854	62.302	13	.000

- It indicates that the discriminant function is significant. Also, it indicates that 85.4% cases are unexplained (not-misclassified).

Structure Matrix Table

	Function
	1
F Scale	.841
Paranoia	.761
Hypomania	.564
Psychasthenia	.475
Introversion	.365
Hypochondriasis	.353
K Scale	-.318
Hysteria	.008

The relative importance of the predictors and their direction can be understood from the table.

The Discriminant Function Coefficients

	Function
	1
F Scale	.043
K Scale	.033
Hypochondriasis	-.001
Hysteria	-.033
Paranoia	.044
Psychasthenia	-.015
Hypomania	.023
Introversion	.025
(Constant)	-7.024

$$D = 0.043 \text{ F scale} + 0.033 \text{ K Scale} - 0.001 \text{ Hypo} - 0.033 \text{ Hysteria} + 0.044 \text{ Paranoia} - 0.015 \text{ Psych} + 0.023 \text{ Hypo} + 0.025 \text{ Intro} - 7.024$$

The Group Centroids

Consensus diagnosis	Function
	1
No Schizophrenia	-0.17
Have Schizophrenia	0.88

The group means of the discriminant scores are called as the centroids.

This values of centroids help in classification.

We can also use the classification function

Classification Function Coefficients

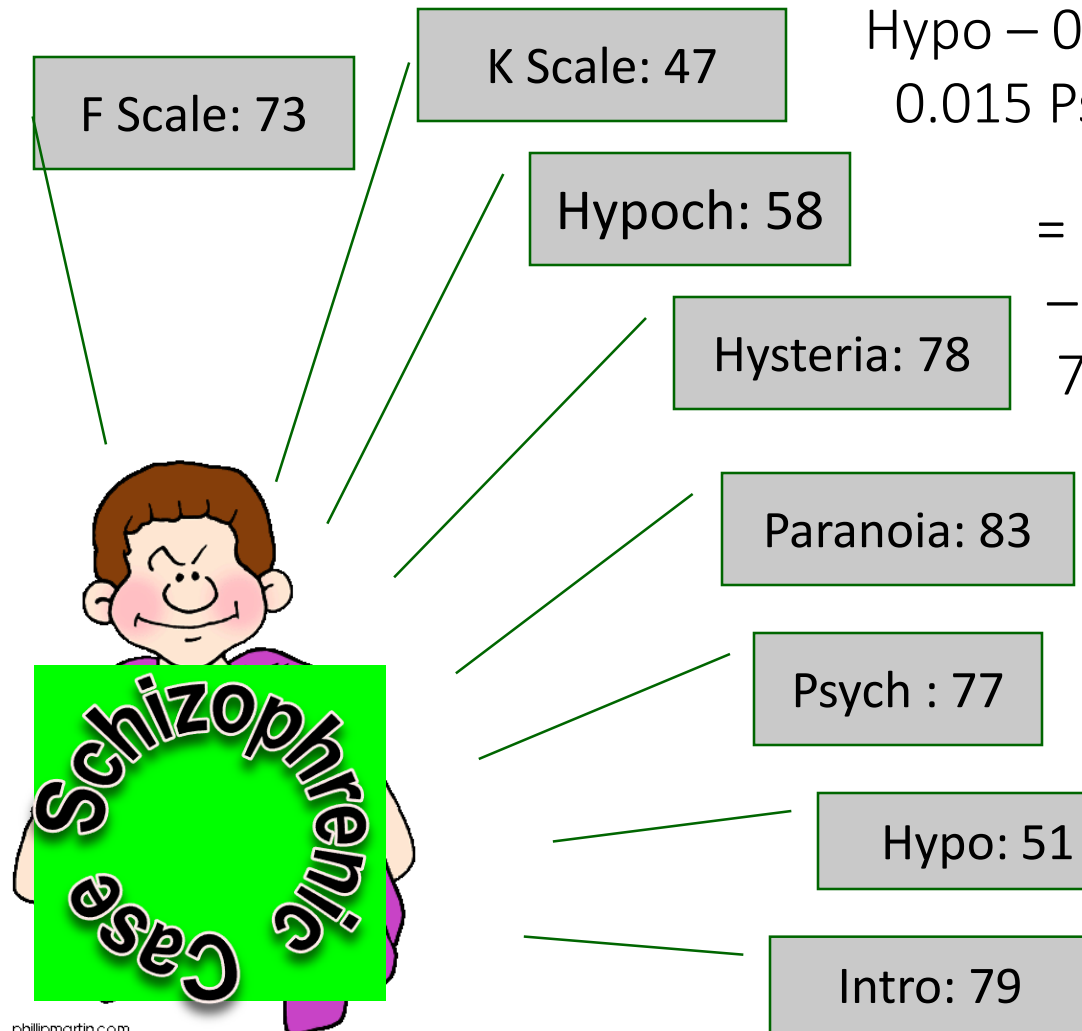
	Consensus diagnosis	
	0	1
F Scale	-.058	-.012
K Scale	2.461	2.495
Hypochondriasis	.423	.422
Hysteria	-.395	-.430
Paranoia	-.234	-.189
Psychasthenia	.700	.684
Hypomania	1.081	1.105
Introversion	1.076	1.102
(Constant)	-137.559	-145.308

Fisher's linear discriminant functions

$$G_0 = -0.058 \text{ F scale} + 2.461 \text{ K Scale} + 0.423 \text{ Hypo} - 0.395 \text{ Hysteria} - 0.234 \text{ Paranoia} - 0.7 \text{ Psych} + 1.081 \text{ Hypo} + 1.076 \text{ Intro} - 137.559$$

$$G_1 = -0.012 \text{ F scale} + 2.495 \text{ K Scale} + 0.423 \text{ Hypo} - 0.43 \text{ Hysteria} - 0.189 \text{ Paranoia} - 0.684 \text{ Psych} + 1.105 \text{ Hypo} + 1.102 \text{ Intro} - 145.308$$

How the classification works?

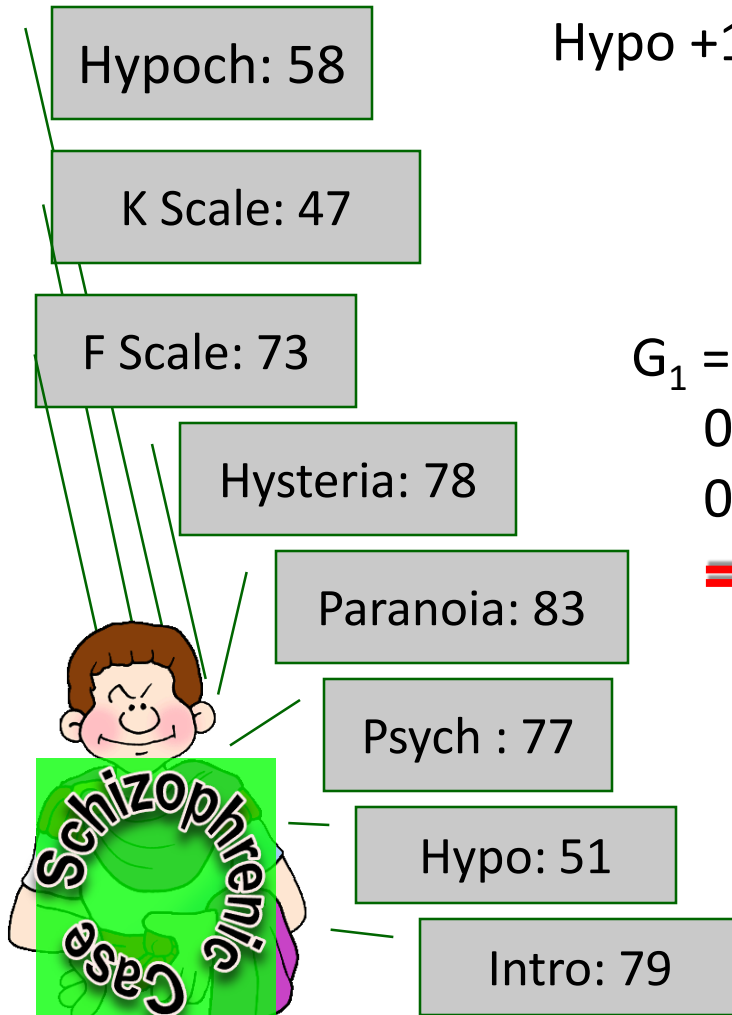


$$\begin{aligned}
 D &= 0.043 \text{ F scale} + 0.033 \text{ K Scale} - 0.001 \\
 &\text{Hypo} - 0.033 \text{ Hysteria} + 0.044 \text{ Paranoia} - \\
 &0.015 \text{ Psych} + 0.023 \text{ Hypo} + 0.025 \text{ Intro} - \\
 &\quad 7.024 \\
 &= 0.043 \times 73 + 0.033 \times 47 - 0.001 \times 58 \\
 &\quad - 0.033 \times 78 + 0.044 \times 83 - 0.015 \times \\
 &\quad 77 + 0.023 \times 51 + 0.025 \times 79 - 7.024 \\
 &= 0.679
 \end{aligned}$$

Group Centroids	
No Schizophrenia	Have Schizophrenia
- 0.17	+ 0.88

Using the Classification Function

$$G_0 = -0.058 \text{ F scale} + 2.461 \text{ K Scale} + 0.423 \text{ Hypo} - 0.395 \text{ Hysteria} - 0.234 \text{ Paranoia} - 0.7 \text{ Psych} + 1.081 \text{ Hypo} + 1.076 \text{ Intro} - 137.559 = 34$$



$$G_1 = -0.012 \text{ F scale} + 2.495 \text{ K Scale} + 0.423 \text{ Hypo} - 0.43 \text{ Hysteria} - 0.189 \text{ Paranoia} - 0.684 \text{ Psych} + 1.105 \text{ Hypo} + 1.102 \text{ Intro} - 145.308 = 37$$

Classification Results

			Predicted Group Membership		Total
			0	1	
Original	Count	0	321	16	337
		1	53	12	65
	%	0	95.3	4.7	100.0
		1	81.5	18.5	100.0
Cross-validated ^b	Count	0	320	17	337
		1	54	11	65
	%	0	95.0	5.0	100.0
		1	83.1	16.9	100.0

Here 69 cases out of 402 cases are misclassified.
Thus, 82.8% cases are correctly classified.

Saved Variables

- Two new variables shall now be added to your data file
- One containing the discriminant score from the function
- The other is the predicted group of the observation.

Summarizing the result

- A discriminant analysis was conducted to predict if a patient is schizophrenic or not.
- The predictor variables were Lie Scale, F Scale, K Scale, Hypochondriasis, Depression, Hysteria, Psychopathy, Masc / Fem, Paranoia, Psychasthenia, Schizophrenia, Hypomania, Introversion.
- Significant mean difference was observed in the predictor variables F Scale, K Scale, Hypochondriasis, Psychopathy, Psychasthenia, Paranoia, Schizophrenia, Hypomania and Introversion which were retained in the further analysis

Summarizing (continued...)

- The equality of covariance matrix of the two groups were attained
- The discriminant function was able to classify 85.4% cases successfully.
- Out of the predictors that were statistically significant we find that F Scale, Paranoia, and Hypomania are the very strong predictors.